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THE PLASTIC EXTENSION OF A CHAIN OF RINGS DUE TO AN AXIAL IMPACT LOAD

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Summary—The plastic response of a chain of circular rings due to an axial tensile impact load was investigated both experimentally and in part, analytically. Chains were built-up from circular aluminium rings and subjected to axial impact loading at one end. High-speed photography was employed to record the development of the deformation process. It was found that plastic collapse was progressively transmitted to neighbouring rings in the manner of a plastic wave. To investigate the situation analytically, a simplified approach was adopted which assumed rigid-perfectly plastic behaviour of the ring material and arrived at an equation of the same form as the classical one-dimensional elastic wave equation.

NOTATION

L length of chain
M bending moment
M_o attached mass
M_p fully plastic bending moment
N number of rings or resultant circumferential force
N_y yield force of cross section of ring
P force, in general
P_o collapse point load of a ring
R mean radius of ring
T kinetic energy
V_o velocity at impact
Y yield stress
a acceleration
b lateral thickness of ring
c_p velocity of "plastic wave"
d mean diameter of ring
h radial thickness of ring
m mass of single ring
t time
u displacement
x axial co-ordinate
δ elongation
ϕ angular co-ordinate
θ inclination of link

1. INTRODUCTION

There are many engineering situations in which it is necessary to bring a moving mass to a halt in a controlled way and several devices have now been proposed for converting the kinetic energy of the moving mass into plastic work. During the last two decades or so a great deal of effort has been expended on the study of energy absorbers, especially by the motor vehicle and aerospace industries. Examples of such devices include thin-walled tube compression, invertubes, tear webbing, harness cables and chains, etc. An easily constructed structure of this same type consists of a